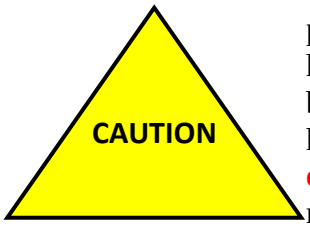
About Ensemble QPF Hydrographs



Disclaimer: These ensembles are based on hydrologic model simulations that incorporate 5 and 95% chance amounts of forecast precipitation as well as a "best estimate" of forecast precipitation, however, the probability of the resultant hydrographs is unknown. These output hydrographs are based on raw model output and have not been reviewed by hydrologists, who, for official river forecasts, add value by adjusting hydrologic model output to account for model limitations. **These ensembles DO NOT represent official river forecasts.** Decision makers should contact their local NWS Weather Forecast Office before taking significant actions based upon an Ensemble QPF Hydrograph.

Please read on to learn more about Ensemble QPF Hydrographs.

1. Background

National Weather Service (NWS) official river forecasts found at http://water.weather.gov show a deterministic or "one best value" hydrograph, which implies a level of certainty in the forecasts. These river forecasts incorporate a number of parameters such as soil moisture conditions due to past rain or snowmelt, and quantitative precipitation forecasts (QPF). In the central U.S., river forecasts typically incorporate forecast precipitation through the next 24 hours.

A number of NWS customers have expressed the need to vary the aspects of future precipitation used in the production of river forecast hydrographs to produce "What if?" scenarios. These variations take on two forms. First, customers would like to vary the duration of the QPF used. In other words, instead of using only the next 24 hours of QPF to generate the river forecast hydrograph, users would like to know the impact of using the next 48-hours of QPF. The second type of variation is with regard to the amount of future precipitation considered for any given duration. That is, instead of using the official QPF amount for the next 24 hours (say one inch), customers would like to know the impact of using greater amounts, say two inches, over the same 24-hour future period.

This new product, Ensemble QPF Hydrographs (EQHs), attempts to address this need to vary the QPF amounts and forecast time periods used in the production of river forecast hydrographs to show multiple river level scenarios. Generating EQHs using 0, 24, 48 and/or 72 hours of the official forecast precipitation (QPF) is a straightforward concept. Varying the amount of QPF (for any given duration) is not so clear-cut. The use of the NWS Hydrometeorological Prediction Center's (HPC) Probabilistic QPF (PQPF) in these EQHs addresses this need to vary the amount of QPF for a given duration (forecast time period) in a way which accounts for meteorological uncertainty in the precipitation forecast.

The HPC produces probabilistic QPF by utilizing a probability distribution generated from numerous meteorological models that constitute an ensemble of meteorological forecasts. Further detail regarding HPC's PQPF methodology can be found at http://www.hpc.ncep.noaa.gov/pqpf/conus_hpc_pqpf.php.

2. Ensemble QPF Hydrographs (EQH)

The minimum and maximum Ensemble QPF Hydrographs show the hydrologic response to HPC's PQPFs using the 5th and 95th percentiles, respectively. The "best estimate" EQH shows the hydrologic response using the RFC-determined "best estimate" QPF. The source of this best estimate is indicated in the legend on the graphic. These three scenarios are combined with a zero precipitation scenario, resulting in a 4-hydrograph ensemble for each forecast period of 24, 48 and 72 hours. The percentile value is the percent chance of precipitation accumulating less than a particular amount. From the opposite perspective, 100 minus the percentile is the chance of precipitation reaching or exceeding that amount. That is, the 95th percentile PQPF has a 5% chance of being exceeded. Examples are shown in Figures 2 and 3.

An annotated example of an EQH graphic is shown in Figure 1, below. The amount and timing of the QPF as applied to the river location's immediately surrounding area is depicted in the *Local Rainfall* section of the graphic, and the local rainfall is color coded to correspond with the appropriate EQH hydrograph.

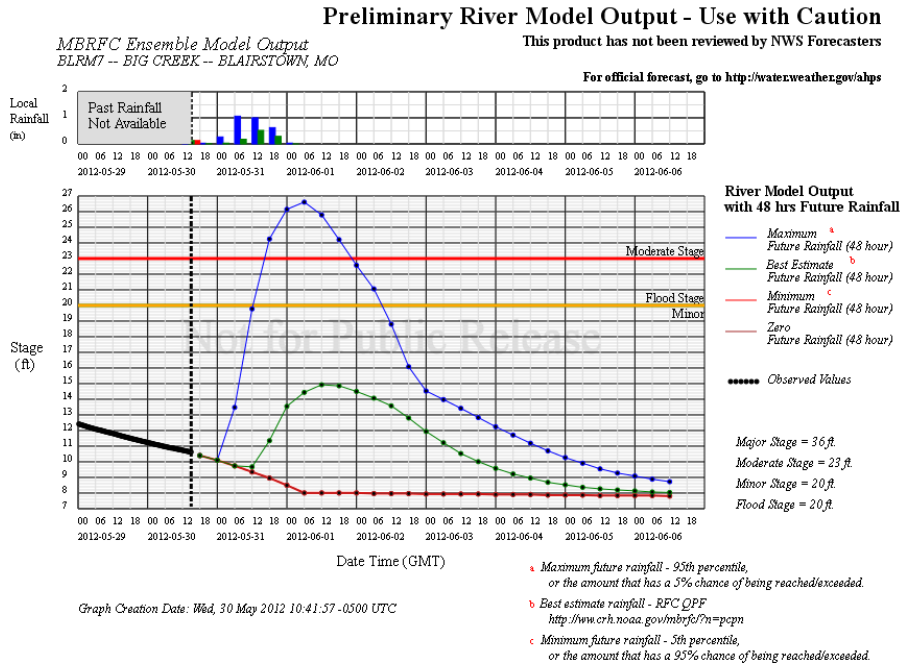


Figure 1. Ensemble QPF Hydrograph

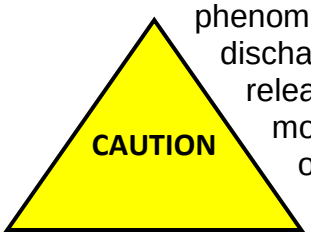
3. Ensemble QPF Hydrographs: Advantages and Challenges

The EQH product has many advantages, including automated production that enables the generation of multiple solutions with little resource allocation. The NWS is working toward providing a seamless suite of short-term (<14 days) probabilistic river forecasts (analogous to the current production of long-term probabilistic river forecasts such as 30-day, 90-day, etc.), that will take into account both uncertainty in the model performance, as well as the uncertainty in the model forcings such as forecast precipitation. In the interim, the EQH provides the customer with a "statistically-based spread" of the hydrologic solutions given just a variance in the precipitation scenario.

Nevertheless, while the EQH has advantages, it also is not without its interpretive challenges. Difficulties in using EQH for decision making fall into two main categories: river forecast model limitations and QPF uncertainties. Both categories are to some degree the result of the automatic production approach.

a. Model limitations

The hydrologic model used to produce river forecasts is a tool, not an infallible guide. Hydrologic model inaccuracies can stem from many sources, including hydraulic phenomena (backwater effects, routing assumptions, changing stage-discharge relationships), and regulation activities (unscheduled reservoir releases, diversion operations). As the river forecaster works with the model to produce a forecast, he or she must make modifications based on scientific reasoning and expertise. These forecaster modifications may frequently produce an official NWS deterministic river forecast that does not agree with the EQH graphic. Situations may arise where the official NWS river forecast may be below the EQH zero QFP forecast. In addition, the general shape or hydrologic response of the EQH hydrograph may not agree with the shape or hydrologic response of the official NWS river forecast hydrograph.



b. QPF Uncertainties.

The QPF can vary from what actually occurs in three ways: timing, location, and amount. The PQPF has a further interpretive challenge: how to interpret the actual probability of occurrence. That is, given that the precipitation at any one grid location may have only a 5% chance of exceeding the 95th percentile amount, what is the resultant probability of all the grids in a given watershed exceeding their 95th percentile amount at the same time? Also, it is unclear as to the resultant probability of a given watershed experiencing the 95th percentile precipitation in back-to-back six-hour periods. Therefore, it is strongly encouraged that decision makers contact their local NWS Weather Forecast Office before taking significant actions based upon an EQH. Figure 4 shows the rainfall that actually occurred in the 24 hours ending March 28, 2012. Comparing this with Figures 2 and 3 that show the 95 and 5% chance QPFs for

the same time period, one can get an indication of the variance between the maximum and minimum QPF solutions versus what actually occurred.

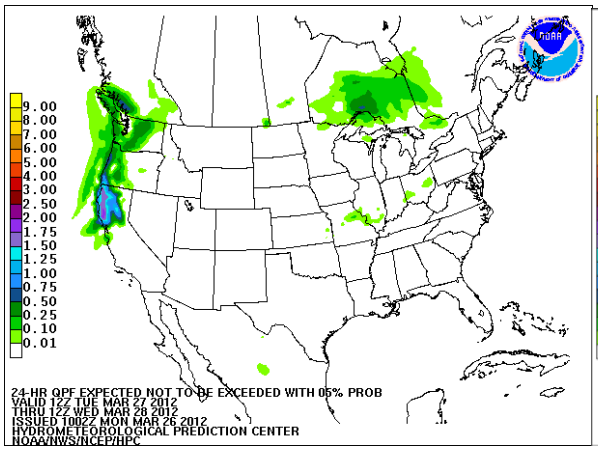


Figure 2. 24-hour QPF with 95% chance of being exceeded

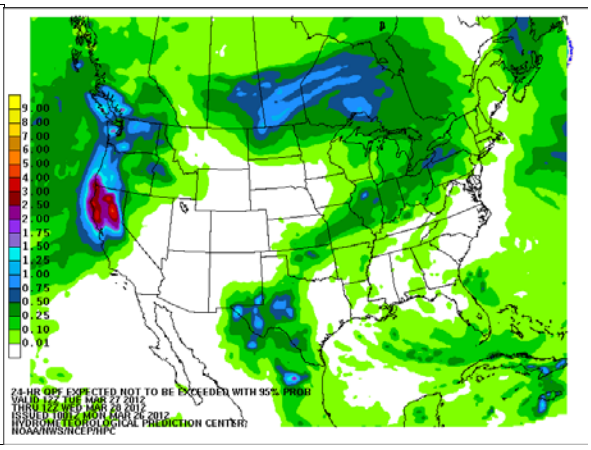


Figure 3. 24-hour QPF with 5% chance of being exceeded

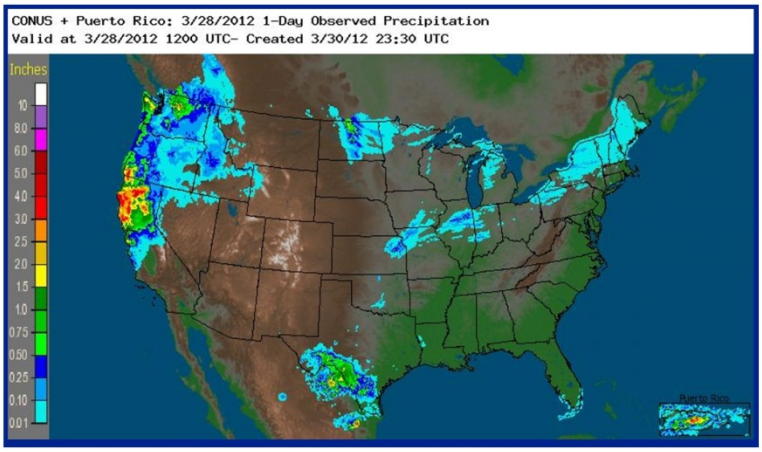


Figure 4. 24-hour Observed Precipitation valid March 28, 2012

The uncertainty and impact of QPF on the river forecast can be seen in Figures 5 through 7. Figure 5 shows a maximum QPF for a 24-hour period in the upper left picture and the corresponding observed rainfall to the lower right. The basin area in the vicinity of Kansas City received about two inches less rainfall than forecast. The impact can be seen in Figure 6 where the maximum EQH indicated a crest about 25 feet higher than what actually occurred. Figure 7 shows an example where the observed precipitation was much closer to the maximum QPF resulting in the observed hydrograph being closer to the maximum 72-hour EQH rather than what was actually forecast (the green trace).

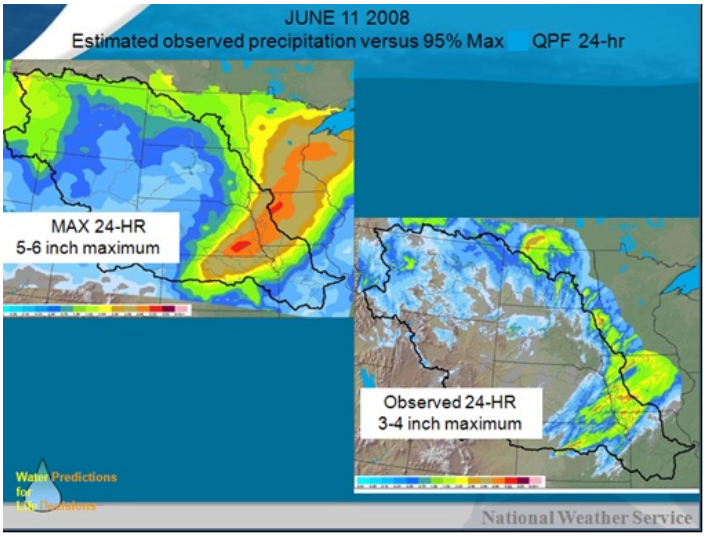


Figure 5. Comparison of maximum QPF and observed precipitation

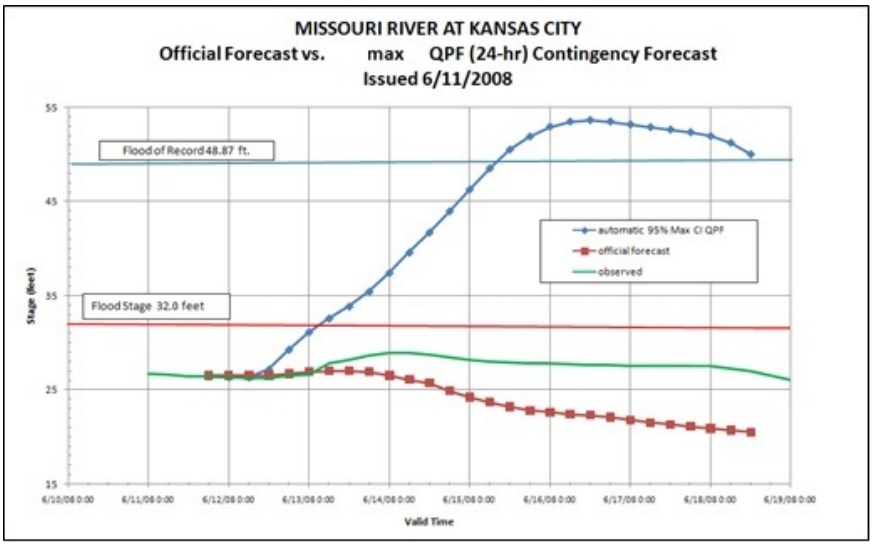


Figure 6. Comparison of maximum EQH with observed and official forecast

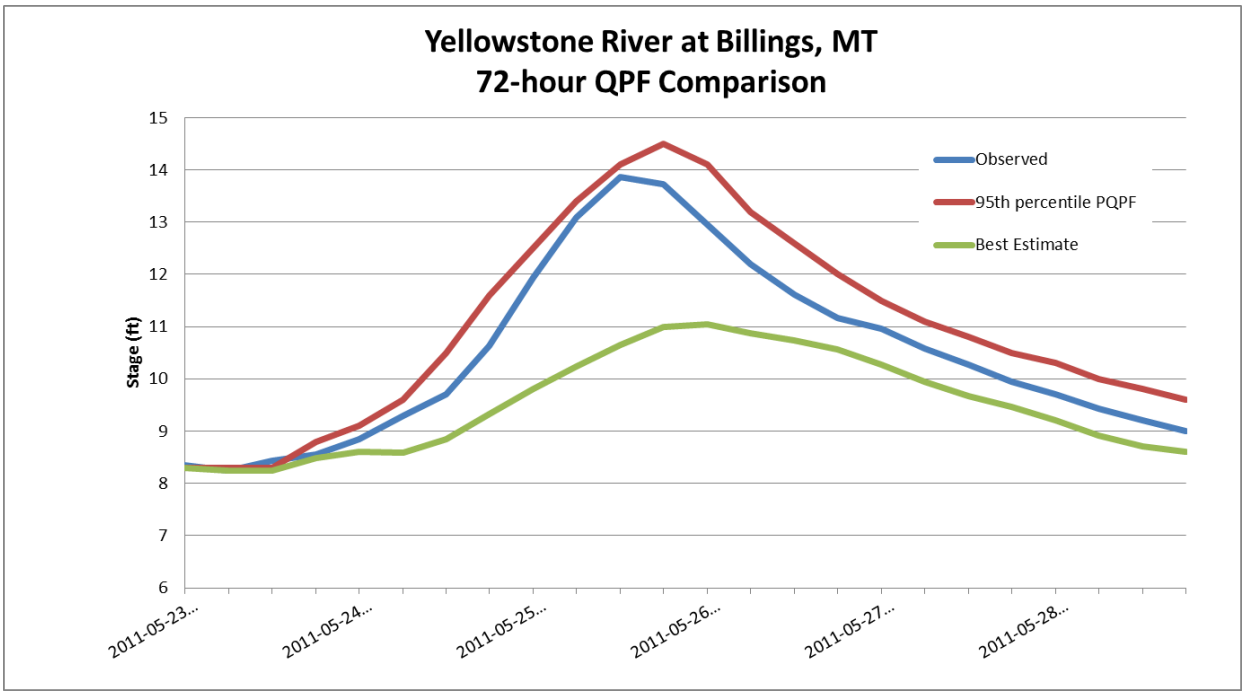


Figure 7. Comparison of maximum EQH with observed and best estimate QPF hydrograph